PATENT ABSTRACTS OF JAPAN

(11)Publication number : 2002-134318
(43)Date of publication of application : 10.05.2002

(51)Int.Cl. H01F 10/16
C25D 3/56
C25D 7/00
G11B 5/31
H01F 41/18
H01F 41/26

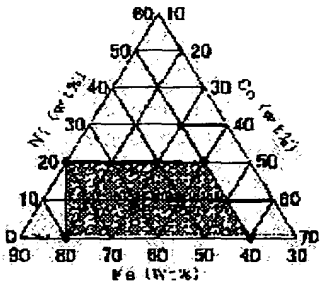
(21)Application number : 2000-326346
(22)Date of filing : 26.10.2000

(71)Applicant : FUJITSU LTD
(72)Inventor : SHIMIZU SANAE
ODAGIRI MITSURU
MIYAKE HIROKO

(54) MAGNETIC THIN FILM, METHOD OF MANUFACTURING THE SAME, AND MAGNETIC HEAD

(57)Abstract:
PROBLEM TO BE SOLVED: To obtain an FeCo plating film which is high in saturation magnetic flux density and kept free from pits and crackings, without adding a nonmagnetic metal concerning the magnetic thin film, a method of manufacturing the same, and a magnetic head.
SOLUTION: The compositional weight ratio of Fe, Co, and Ni, contained in an FeCo plating film, indicates that it is included in a square region possessed of four apexes, represented by Fe80Co20, Fe40Co60, Fe40Co40Ni20, and Fe70Co10Ni20, and furthermore the compositional ratio of Ni is set at 1 wt.% or higher.

本発明に実施の形態の磁性薄膜の好適な組成範囲の説明図



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[Date of request for examination]

[Date of sending the examiner's decision of rejection]

[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]

[Date of final disposal for application]

[Patent number]

[Date of registration]

[Number of appeal against examiner's decision of rejection]

[Date of requesting appeal against examiner's decision of rejection]

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CLAIMS

[Claim(s)]
[Claim 1] The magnetic thin film which the weight-composition ratio of Fe, Co, and nickel is contained to 4 square-shape field which makes a vertex Fe80Co20, Fe40Co60, Fe40Co40nickel20, and Fe70Co10nickel20, and is characterized by nickel composition ratio being 1 % of the weight or more.
[Claim 2] The manufacture method of the magnetic thin film characterized by Fe ion/under plating bath containing Fe ion, Co ion, and nickel ion (Fe ion +Co ion) using the plating bath which are 0.3 <=Fe ion / (Fe ion +Co ion) <1.0 in the manufacture method of a magnetic thin film according to claim 1.
[Claim 3] The manufacture method of the magnetic thin film according to claim 2 characterized by making the organic unsaturated compound which has carbon triple bond or a carbon double bond during the above-mentioned plating bath, excluding [=C-SO2-] structure contain.
[Claim 4] The manufacture method of a magnetic thin film according to claim 3 that the organic unsaturated compound which has the above-mentioned carbon triple bond or a carbon double bond is characterized by being 2-propyne-1-oar.
[Claim 5] The magnetic head characterized by the thing of the up magnetic pole of the aforementioned induction-type thin film magnetic head, and a lower magnetic pole for which the magnetic thin film according to claim 1 was used in part at least in the magnetic head equipped with the induction-type thin film magnetic head at least.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[The technical field to which invention belongs] this invention is the high saturation magnetic flux density Bs especially used for magnetic devices, such as an up magnetic pole core for the induction-type thin film magnetic heads of a hard disk drive (HDD), and a thin film transformer, about the manufacture method of a magnetic thin film and a magnetic thin film, and the magnetic head. It is related with the manufacture method of the magnetic thin film which has the feature in the composition for obtaining a plating film, and a magnetic thin film, and the magnetic head.
[0002]
[Description of the Prior Art] In recent years, recording density of the hard disk which is the external storage of a computer improves by one times the speed of an annual rate, the element size of the magnetic head is also small, high coercive force-ization of a record medium is progressing, and the magnetic material which has sufficient write-in capacity also to such a record medium of high coercive force is demanded.
[0003] It is saturation magnetic flux density Bs as the up magnetic pole core which constitutes the induction-type thin film magnetic head in order to have sufficient write-in capacity also to the record medium of high coercive force or an up magnetic pole core, and a lower magnetic pole layer. Using a high material has the need and it is made indispensable [Bs >=2.0T] with the request of a raise in recording density in recent years at the portion which magnetic flux concentrates most in the future.
[0004] Moreover, since it is the configuration which magnetic pole material has 3-4-micrometer thickness so that magnetic flux sufficient at a nose of cam may generate such the induction-type thin film magnetic head, and has a level difference, with vacuum membrane formation technology, such as the sputtering method currently used abundantly as other magnetic material deposition methods, the etching method that the efficiency of a membrane formation rate is bad, and effective is not established. Therefore, in the former, deposit efficiency is high and the magnetic pole is formed by the electroplating method excellent in selection membrane formation by using a resist frame.
[0005] As a magnetic pole material for writing of the conventional induction-type thin film magnetic head, although the NiFe alloy thin film, i.e., a permalloy, is generally used, incidentally, the saturation magnetic flux density of nickel80Fe20 currently conventionally used abundantly, i.e., 80NiFe, is Bs =1.0T, and the saturation magnetic flux density of nickel50Fe50, i.e., 50NiFe, is Bs =1.5T.
[0006] However, as a magnetic material which whose NiFe is inadequate and responds to the request of a raise in saturation magnetic flux density to the request of an above-mentioned raise in saturation magnetic flux density, it sets into a magnetic alloy and is the highest saturation magnetic flux density Bs. The FeCo alloy obtained attracts attention. Incidentally, 2.45T are obtained in Fe60Co40 of bulk (if required R.M.Bozorth, IEEE Press, p.80, 1993 references).
[0007] In forming the high magnetic material of such a Fe composition ratio, it is necessary to raise Fe ion concentration under plating bath enough as compared with the existing NiFe etc., and the amount from which bivalent Fe ion changes to trivalent Fe ion also increases with the

increase in Fe composition ratio.
[0008] When trivalent Fe ion exists during a plating bath, generally it is weak, and is easy to become the plating film of a black ash color with big stress, and problems, such as producing a pit and a crack on a plating film, arise, and it becomes impossible thus, to disregard the augend of trivalent Fe ion under plating bath.
[0009] Then, in order to solve such a problem, to add metal ions, such as Pd, Cu, Pt, Au, Ag, Ir, Rh, and Ru, during the plating bath containing Fe ion and Co ion is tried (refer to JP,5-29172,A, if required).
[0010]
[Problem(s) to be Solved by the Invention] However, when metal ions, such as Pd and Cu, are added during a plating bath, since these metals are non-magnetic metal, they have the problem that the saturation magnetic flux density of the obtained plating film will fall.
[0011] Therefore, this invention aims at obtaining the plating film of the FeCo system of high saturation magnetic flux density with which generating of a pit or a crack was suppressed, without adding non-magnetic metal.
[0012]
[Means for Solving the Problem] Here, with reference to drawing 1 , the The means for solving a technical problem in this invention is explained. In addition, drawing 1 is the triangular composition diagram showing the composition range of FeCoNi of this invention.
In order to attain with the drawing 1 referring-to-above-mentioned purpose, in a magnetic thin film, this invention is contained to 4 square-shape field to which the weight-composition ratio of Fe, Co, and nickel makes a vertex Fe80Co20, Fe40Co60, Fe40Co40nickel20, and Fe70Co10nickel20, and is characterized by nickel composition ratio being 1 % of the weight or more.
[0013] nickel is saturation magnetic flux density Bs, when it adds as the third element unlike Pd or Cu since it was a magnetic element, although the magnetic moment was small as compared with Fe or Co. A fall can be suppressed to the minimum.
[0014] Moreover, nickel is hard, excellent in chemical resistance and glossiness so that clearly also from being extensively used as a plating material, and it has the feature that good plating is easy to be obtained, and it becomes possible to prevent the pit which is easy to generate with the increase in Fe, and a crack.
[0015] Therefore, it is the surface roughness Ra by carrying out nickel composition ratio to 1% of the weight or more in the big FeCo system alloy of such a Fe composition ratio. It is small, for example, it becomes possible more suitably high saturation magnetic flux density, Bs >=2.0T [for example,], and to form the magnetic thin film of Bs >=2.2T with sufficient repeatability less than [Ra <200nm]. In addition, surface roughness Ra in this case It is the arithmetic mean granularity specified in JIS B0601 -1994 convention. When a surface roughness curve is made into y=f (x), it integrates with the absolute value of y=f (x) over the criteria length L. Surface roughness Ra [in / this specification / it is the value standardized by the criteria length L, and] Or roughness Ra The arithmetic mean granularity altogether specified in JIS B0601 -1994 convention is meant.
[0016] In addition, in [NiFe] this case, as a plating base layer, it is the same system as a plating film, and it is desirable to use, the big FeCoNi film 11, for example, Fe26Co63nickel, of saturation magnetic flux density, and it can raise the saturation magnetic flux density of an up magnetic pole core or the whole lower magnetic pole layer by it.
[0017] Moreover, this invention is characterized by Fe ion/under plating bath containing Fe ion, Co ion, and nickel ion (Fe ion +Co ion) using the plating bath which are 0.3 <=Fe ion / (Fe ion +Co ion) <1.0 in the manufacture method of a magnetic thin film.
[0018] Thus, in order to obtain the FeCo system magnetic thin film of high saturation magnetic flux density, for that, it is necessary to make Fe composition ratio or more into 0.4, and to make Fe ion/under plating bath (Fe ion +Co ion) into 0.3 <=Fe ion/(Fe ion +Co ion).
[0019] In this case, it is desirable to make the organic unsaturated compound which has carbon triple bond or a carbon double bond during a plating bath, excluding [=C-SO2-] structure, for example, 2-propyne-1-oar, [PPO, molecular formula:HC**C-CH2-OH] contain, and it is surface

roughness Ra by it. Membrane formation of a small plating film is attained.
[0020] Moreover, this invention is characterized by the thing of the up magnetic pole of the induction-type thin film magnetic head, and a lower magnetic pole for which the above-mentioned magnetic thin film was used in part at least in the magnetic head equipped with the induction-type thin film magnetic head at least.
[0021] Thus, by using the above-mentioned magnetic thin film, highly-efficient-izing and low-cost-izing of the magnetic head are attained, as a result highly efficient-ization of magnetic storage is attained. In addition, in this case, an up magnetic pole and the whole lower magnetic pole may be constituted, any direction or one side may be constituted, or it is the thing of an up magnetic pole and a lower magnetic pole which may be used as a letter magnetic pole core of a chip of a point at least.
[0022]
[Embodiments of the Invention] Here, with reference to drawing 2 or drawing 6 , the manufacture method of the magnetic thin film of the form operation of this invention is explained. electrolysis plating is performed using the paddle equipment which makes the conventional technology the plating equipment used in the form of operation of this invention, and is generally used, stirring a plating bath with this paddle equipment, and the configuration of a paddle and distance with the substrate on which a magnetic thin film is made to deposit, i.e., distance with a cathode, rotational speed, etc. are not set up arbitrarily if needed, and are not limited especially
[0023] Moreover, the plating bath used for the form of operation of this invention A ferrous sulfate (FeSO4 and 7H2 O), a nickel sulfate (NiSO4 and 6H2 O), The metal ion ratio of concentration under plating bath a cobalt sulfate (CoSO4 and 7H2 O) and by Fe2+:Co2+=30:70-100:0 And while adjusting pH to 2.0-3.5, 2.5 [for example,], by mixing so that it may be set to nickel2+:(Fe2++Co2++nickel2+) =0.01:100-80:100, and adding 30g /of way acids I. An ammonium chloride adjusts conductivity and what added further 0.2g /of sodium dodecyl sulfates which are a surfactant I. is used. Moreover, an ascorbic acid is added as an antioxidant.
[0024] Performing-using such plating bath-electrolysis plating **** is SiO2 to a front face as a substrate. After thickness forms 10nm Ti film by the sputtering method in order to improve adhesion while using Si substrate in which the film was formed, thickness forms a 50nm FeCoNi film by the sputtering method as a plating base layer. In addition, the weight-composition ratio of a FeCoNi film is taken as Fe26Co63nickel11.
[0025] Subsequently, it is 2mA [5-20 //cm] at the temperature of room temperature -40 degree C, for example, 30 degrees C. The FeCoNi magnetic thin film was formed on the FeCoNi film which performs electrolysis plating in the direct-current magnetic field more than 400 [Oe], for example, the direct-current magnetic field of 400 [Oe], and serves as a ground with two or more current density of a between.
[0026] Drawing 2 reference drawing 2 is explanatory drawing of nickel composition ratio dependency of the membrane formation rate of a plating film, and it is in the state which fixed the Fe2+/Co2+ ratio under Fe2+:Co2+=50:50 and plating bath in this case, and nickel2+ concentration is changed, a membrane formation rate is investigated, and nickel composition ratio in drawing shows the weight ratio of nickel in a plating film.
[0027] When going up was understood and it did not contain nickel ion during a plating bath, the membrane formation rate was not able to be substantially formed with the increase in nickel composition ratio, so that clearly from drawing. By containing nickel ion during the plating bath, this had a catalysis in nickel itself, and while nickel itself tended to have deposited, it thought for promoting a plating reaction, and 0.05-micrometer membrane formation rate for /was obtained [in / 1.0 % of the weight / in nickel composition ratio] to the weight of a plating film.
[0028] Drawing 3 reference drawing 3 is surface roughness Ra of the plating film in the same membrane formation conditions as the case of drawing 2 . It is explanatory drawing of nickel composition ratio dependency. It is surface roughness Ra in the increase in nickel composition ratio so that clearly from drawing. A bird clapper is understood small.
[0029] This is considered to be the result of the pit which is easy to produce with the increase in Fe stopping a crack, since nickel had the feature that excel in glossiness from the first and a good plating film is obtained. Incidentally, to the weight of a plating film, in 1.0 % of the weight,

nickel composition ratio is Ra **200nm, and is stabilized in about Ra **10nm at 5 % of the weight or more.
[0030] Drawing 4 reference drawing 4 is the saturation magnetic flux density Bs of the plating film in the same membrane formation conditions as the case of drawing 2 . It is explanatory drawing of nickel composition ratio dependency. It is saturation magnetic flux density Bs in the increase in nickel composition ratio so that clearly from drawing. Falling is understood. In addition, the white round head in drawing is the reference value (R.M.Bozorth which is the above if required, IEEE Press, p.80, 1993 references) of nickel=0% of the weight of a case, and is Bs **2.4T.
[0031] Although nickel of this is a magnetic element, compared with Fe or Co, it is because the magnetic moment is small, therefore with the increase in nickel composition ratio, although saturation magnetic flux density Bs fell, when nonmagnetic elements, such as Cu and Pd, are added like before, it compares, and it is saturation magnetic flux density Bs. A fall can be suppressed. Incidentally, it is set to Bs **2.0T at nickel**20 % of the weight, and a measurement error can maintain the saturation magnetic flux density of Bs **2.2T until nickel composition ratio of a certain thing becomes 15% of the weight.
[0032] Drawing 5 reference drawing 5 is in the state which fixed the Fe2+/Co2+ ratio under Fe2+:Co2+=50:50 and plating bath like the case of drawing 2 . nickel2+ concentration 4, i.e., NiSO, The amount of nickel deposits in the plating film at the time of changing concentration (% of the weight) is measured, and the mole ratio of NiSO4/(FeSO4+CoSO4+NiSO4) shows nickel2+ concentration.
[0033] As mentioned above, it is NiSO4 during a plating bath. It is NiSO4 so that from drawing and it may become NiSO4 / (FeSO4+CoSO4+NiSO4) = 0.01-mol %, although membranes were not able to be formed when not adding. When it adds, as for the amount of nickel deposits in a plating film, about 1.0 % of the weight and a bird clapper are understood.
[0034] Drawing 6 reference drawing 6 is FeSO4 of the deposit quantitative ratio of Fe and Co. CoSO4 It is drawing having shown the ratio-of-concentration dependency, and is NiSO4 under plating bath. It is in the state which fixed concentration with 0.01-mol %, and they are FeSO4 / CoSO4. The deposit quantitative ratio of Fe and Co in the plating film at the time of changing a ratio is investigated. In addition, the ratio of concentration in a plating bath shows FeSO4/ (FeSO4+CoSO4) by mol %, and the deposit quantitative ratio shows Fe/(Fe+Co) by weight %.
[0035] clear from drawing -- as -- FeSO4 -- with the increase in / (FeSO4+CoSO4), if increasing to a linear mostly understands and carries out inclination extrapolation of Fe/(Fe+Co), the upper limit of Fe composition ratio will become 80%
[0036] On the other hand, since it is making Fe composition ratio increase from membrane formation conditions although the minimum of Fe composition ratio does not exist in order to obtain the magnetic film of high saturation magnetic flux density, as for Fe composition ratio, it is desirable to make it to 40% or more, and it is desirable to make it to 50% or more especially. If drawing 6 is incidentally referred to in order to make Fe composition ratio 40% or more, it will be understood that a measurement error needs to carry out FeSO4/(FeSO4+CoSO4) of a certain thing more than 30 mol %.
[0037] By adding nickel to a FeCo system plating bath, if the above is collectively considered in synthesis, a membrane formation rate is raised and it is surface roughness Ra. Since it can be made small As a nickel composition ratio in a plating film, it is desirable to consider as 2.0 % of the weight or more more suitably 1.0% of the weight or more, and they are a membrane formation rate, surface roughness Ra, and saturation magnetic flux density Bs. In order to acquire the property which was excellent about all, it is desirable to consider as 5.0 % of the weight or more.
[0038] If the purpose of obtaining the high saturation-magnetic-flux-density film from the first which is Bs >=2.0T is taken into consideration, it is desirable for nickel composition ratio to consider as 20 or less % of the weight, and in order to be referred to as Bs **2.2T, it will be desirable [on the other hand, in order to attain high saturation magnetic flux density so that clearly from drawing 4 , nickel composition ratio has the smaller desirable one and] to consider as 15 or less % of the weight.
[0039] Moreover, Fe/(Fe+Co) also has a limit and, as for the composition ratio of Fe, it is

desirable to carry out to 40 % of the weight - 80% of the weight as mentioned above so that clearly from drawing 6 .

[0040] Again, drawing 1 reference drawing 1 shows the suitable composition range which summarized the above, and he includes the composition range to 4 square-shape field which makes a vertex Fe80Co20, Fe40Co60, Fe40Co40nickel20, and Fe70Co10nickel20, and it is understood that the field whose nickel composition ratio is 1 % of the weight or more is suitable.

[0041] Therefore, record to a high coercive force magnetic-recording medium is attained in the above-mentioned condition ****** magnetic thin film by [of the induction-type (inductive) thin film magnetic head] supposing a part and using at least. For example, it sets to the inductive thin film magnetic head of the shape of a KO character which the up-and-down magnetic pole layer combined at the center of a light coil. You may constitute from two-layer structure where the inside serves as a magnetic thin film of this invention. In order to narrow core width of face, in the case of the magnetic pole of the CHIPPUDO type which prepared the salient of **** which counters mutually up and down in the point, i.e., the light pole, of a vertical magnetic pole layer That what is necessary is for the magnetic thin film of this invention just to constitute this salient, record to a high coercive force magnetic medium is attained, and improvement in recording density is attained by it.

[0042] As mentioned above, although the gestalt of operation of this invention has been explained, this invention is not restricted to the composition indicated in the gestalt of operation, and various kinds of change is possible for it. For example, in the gestalt of the above-mentioned operation, although the ammonium chloride is used as a reagent for raising the conductivity of a plating bath, it is not restricted to an ammonium chloride and a sodium chloride or an ammonium sulfate may be added.

[0043] Moreover, although the plating bath not containing, organic additives, i.e., primary brighteners, such as a saccharin sodium, is used in the gestalt of the above-mentioned operation, it is surface roughness Ra. In order to decrease, you may add organic additives, such as a saccharin sodium.

[0044] In addition, although the primary brightener in nickel plating is a thing of a grade which does not express gloss or gives semigloss if independent It is that in which the gloss which was excellent when used together together with the secondary brightener mentioned later appears. And this primary brightener is what has the effect of reducing the internal stress which a secondary brightener gives. Generally there are many sulfur compounds which have the double bond of [C=C-SO2], [C=C-C-SO2], etc., etc., for example, 1, 3, and 6-naphthalene tris RUHON acid sodium corresponds.

[0045] Furthermore, surface roughness Ra You may add the organic unsaturated compound which is an organic additive without structure of [=C-SO2-] as other methods for decreasing, and has either of the structures of carbon triple bond or a carbon double bond, i.e., a secondary brightener. By adding such an organic unsaturated compound, it is surface roughness Ra. While being able to decrease, the magnetic thin film excellent in corrosion resistance can be obtained.

[0046] In addition, as a secondary brightener which includes carbon triple bond [C**C] as an organic additive, excluding [=C-SO2-] structure, although 2-propyne-1-oar [PPO, molecular formula:HC**C-CH2-OH] is suitable The same [=C-SO2-] structure as the 2-propyne-1-oar instead of what is restricted to 2-propyne-1-oar is not included. And you may use 2-butyne-1-oar or the 2-butyne -1, 4-diol, etc. which are a secondary brightener including carbon triple bond [C**C].

[0047] Furthermore, you may use for example, a sulfone benzaldehyde, a coumarin derivative, etc. which are a secondary brightener including a carbon double bond [C=C], excluding [=C-SO2-] structure.

[0048] Moreover, in the form of the above-mentioned operation, although the ascorbic acid which serves as an antioxidant during a plating bath is added, since a fall inclination is looked at by the membrane formation rate of a plating film when it adds, it is not necessary to necessarily add.

[0049] Moreover, in the form of the above-mentioned operation, although the plating film and the FeCoNi film which is affiliated are used as a plating base layer in order to raise saturation

magnetic flux density, it is not restricted to a FeCoNi film and a NiFe film may be used.
[0050] Moreover, although it is explaining in explanation of the gestalt of the above-mentioned operation on the assumption that it uses for the up magnetic pole layer or lower magnetic pole layer of the thin film magnetic head of an induction type this invention is what it is not restricted to such a use and may be used as a magnetic-shielding layer of the upper and lower sides of the independent MR head only for reproduction. further They are the magnetic-shielding layer of the upper and lower sides of the compound-die thin film magnetic head to which the laminating of the thin film magnetic head and the MR head of an induction type was carried out and the up-and-down whole magnetic pole layer, or its thing that may make a part and may be used.
[0051] Furthermore, this invention is not restricted to the magnetic material used for the magnetic head, and can be used as magnetic-shielding material [in / magnetic-measurement equipment etc.], or a magnetic transformer.
[0052] Here, the detailed feature of this invention is explained.
(Additional remark 1) Magnetic thin film which the weight-composition ratio of Fe, Co, and nickel is contained to 4 square-shape field which makes a vertex Fe80Co20, Fe40Co60, Fe40Co40nickel20, and Fe70Co10nickel20, and is characterized by nickel composition ratio being 1 % of the weight or more.
(Additional remark 2) Magnetic thin film of the additional remark 1 publication characterized by the saturation magnetic flux density of the above-mentioned magnetic thin film being more than 2.0T.
(Additional remark 3) Magnetic thin film given in the additional remarks 1 or 2 characterized by using a FeCoNi film as a plating base layer of the above-mentioned magnetic thin film.
(Additional remark 4) The manufacture method of the magnetic thin film characterized by Fe ion/under plating bath containing Fe ion, Co ion, and nickel ion (Fe ion +Co ion) using the plating bath which are 0.3 <=Fe ion / (Fe ion +Co ion) <1.0 in the manufacture method of the magnetic thin film additional remark 1 publication.
(Additional remark 5) The manufacture method of the magnetic thin film additional remark 4 publication that nickel ion concentration under above-mentioned plating bath is characterized by being 0.01% or more to total metal ion concentration.
(Additional remark 6) The manufacture method of a magnetic thin film given in the additional remarks 4 or 5 characterized by making the organic unsaturated compound which has carbon triple bond or a carbon double bond during the above-mentioned plating bath, excluding [=C-SO2-] structure contain.
(Additional remark 7) The manufacture method of the magnetic thin film additional remark 6 publication that the organic unsaturated compound which has the above-mentioned carbon triple bond or a carbon double bond is characterized by being 2-propyne-1-oar.
(Additional remark 8) The magnetic head characterized by the thing of the up magnetic pole of the aforementioned induction-type thin film magnetic head, and a lower magnetic pole for which the magnetic thin film of a publication was used for additional remark 1 or any 1 of 3 in part at least in the magnetic head equipped with the induction-type thin film magnetic head at least.
(Additional remark 9) Magnetic storage characterized by having the magnetic head of additional remark 8 publication.
[0053]
[Effect of the Invention] In case Fe composition ratio forms the large magnetic thin film of high saturation magnetic flux density according to this invention, the fall of saturation magnetic flux density in the state where it stopped to the minimum, by adding nickel ion to a plating bath The place which contributes to the spread of the magnetic storage which could obtain the good plating film without a pit or a crack, and contributed to RF-izing of the thin film magnetic head and high recording density-ization by it, as a result incorporated highly efficient HDD equipment etc. is large.

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DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is explanatory drawing of the suitable composition range of the magnetic thin film of the gestalt of operation of this invention.
[Drawing 2] It is explanatory drawing of nickel composition ratio dependency of the membrane formation rate of the plating film in the gestalt of operation of this invention.
[Drawing 3] Surface roughness Ra of the plating film in the gestalt of operation of this invention It is explanatory drawing of nickel composition ratio dependency.
[Drawing 4] Saturation magnetic flux density Bs of the plating film in the gestalt of operation of this invention It is explanatory drawing of nickel composition ratio dependency.
[Drawing 5] NiSO4 of the amount of nickel deposits in the gestalt of operation of this invention It is explanatory drawing of a content dependency.
[Drawing 6] FeSO4 of Fe in the gestalt of operation of this invention, and the amount of Co deposits, and CoSO4 It is explanatory drawing of a ratio-of-concentration dependency.

[Translation done.]